and other advantages would result from turning electricity from a servant into a master, from a mere transformer of energy into a source of energy.

But we have to do with things as they are:—One hundred per cent. of water-power turned into a net motor power of thirty-three and a third per cent. on the average of the best results; and certainly a wonderful result in itself—nothing of the kind could possibly be obtained either with a steam or a gas engine, and it points to the direction in which, at all events in the meantime, we have to look for a cheap supply of energy for electric traction.

Electric traction may be looked upon as the most economically difficult application of the electrical transmission of energy. The problem of the supply of electrical energy to a factory, for driving such industrial machines as lathes and sewing-machines, and for its illumination when need be, from an electrical main; the problem of utilising a single large steam-engine within a works for supplying motive power to all the different shops, so as to get rid of the waste and inconvenience of shafting, gearing and belting, is not without its difficulties; but these problems are, from the nature of the case, economically simple. The work that has to be done is of a uniform steady character within a compact space.

The problem of electric traction is quite otherwise; the load is now on, now off; the electrical resistance of the line is always varying with the distance traversed; here there are gradients, there curves; whilst the demand for cars, and the most economical supply of car-loads, are matters all of which have to be taken into consideration, and have their influence on the economy of the undertaking.

Six systems have been employed for supplying the motor on the car with electricity; these are using the rails on which the cars travel as conductors. This was done in the first undertakings at Lichterfelde, and at Brighton in the first instance; having a special rail as conductor either beside or between the rails on which the car travels, as used at Portrush, now at Brighton, and on the City and South London underground electric railway; using underground conductors with an open conduit or slot in the road, as at Budapest, Blackpool, and elsewhere; having an insulated underground conductor, such as that laid down for a short distance near Hammersmith; overhead conductors, the system which has the largest application at present, and first used between Frankfort and Offenbach, and mainly in use in the United States of America, where some 3000 miles of electric tramways are said to exist. In the sixth system the conductors are replaced by storage batteries.

The rails on which the cars run are now seldom used for the transmission of the current, as being an uneconomical application, but the use of the third rail is a simple and convenient method, where, as in this country, a pressure or tension above 500 volts is not permitted, and where a third rail on the surface, as in rural districts, or in special tunnels, is not an inconvenience; in urban districts, on the other hand, underground conductors are more suitable. There are two ways of arranging the circuit in underground conductors; either connecting the positive and negative poles of the generator, to two insulated underground conductors respectively, or connecting one pole to the insulated underground conductors, and the other to the rails, which in the latter case are in continuous conductive connection, besides having cross connections at different points.

The use of thin aërial conducting wires is interesting in connection with the practical appreciation of the fact, which took place some years ago, that electric energy consists of two factors, viz. the electromotive force or tension and the current strength. As it is to the latter only that a metallic conductor offers resistance, a certain amount of energy may be transmitted through a very thin wire, if care is taken that the electromotive force of the current is high enough. This is the system which it is proposed to use on the St. Louis and Chicago Electric Railway. The distance between these two towns is 250 miles, and it is proposed to run the cars at the rate of 100 miles an hour; the line is to be divided into twenty-five sections of ten miles each, and in the centre of each section there will be a transformer station. The current is to be generated at a tension of 500 volts, transformed to a tension of 25,000 volts, at which it will be transmitted to the several transformer stations, and will be there reduced to 3000 volts, transmitted to the wire, and thence to alternating current motors attached to the cars, each driving axle being supplied with a separate motor.

Secondary or storage batteries, which is the sixth system, to which we have referred, are specially suitable for use on existing tramways, on account of their simplicity and immediate applicability. The objections to them are their weight and the necessity of renewing them from time to time. As regards the former, they weigh from 1½ to 2 tons, and increase the weight to be propelled from 20 to 25 per cent., and there seems to be a real difficulty in making these batteries at the same time light and durable. The batteries which are oxidised by the direct action of the current are found to be too heavy for electric traction, and those in which the oxide is mechanically applied have been more generally used, the positive plate having a paste of red lead, Pb_3O_4, and the negative a paste of litharge, PbO. The life of a storage battery depends upon its being discharged at a low rate, whilst in traction high rates of discharge are required. It is the positive plate which becomes disintegrated, and cannot again be brought into the condition of metallic lead; the negative plate lasts for a very long time, and can then be re-cast.

This system has been employed on the Birmingham Electric Tramway. On this line a method of controlling the circuit is in use, obviating the necessity of inserting resistances in the circuit, which is always a wasteful way of employing the current. By this means the driver is able with a switch handle to apply from a fourth to the whole of the power which the batteries can produce; the whole would be available when required to start the tram, or when going up-hill with a heavy load, whilst a fourth would be used when travelling on the level with a light load. There are two other positions in which a half or three-quarters can be used as required.

A consideration of importance in connection with electric traction is the style of motor to be used; it should be able to do its work equally well when starting, when after having started it is under the influence of the full current, or where at the further end of the line the current is reduced by the resistance of the conductor; it must be able to be stopped in a moment, and work efficiently with all variations of speed and load. For these purposes shunt motors are not so suitable as series motors, in which the field-magnet coils are connected up in series with the armature, and hence the latter and compound wound motors are those most frequently used. Its special design depends upon the space at disposal in which to fix it, and upon the gearing—whether spur, chain, or worm gearing—used to transmit its motion to the driving axle of the car. In some instances it is advantageous to drive each pair of wheels by a separate motor.

In conclusion, it may be stated that the present conditions under which electric traction is carried on are altogether in its favour, namely, light tramway cars following one another in frequent succession, and travelling at a moderate speed. What is proposed to be done on the St. Louis and Chicago Railway is something quite different. It will probably be difficult to find passengers enough to fill cars to follow one another at a sufficiently quick rate to make the undertaking pay. And then as regards the very high speeds proposed to be used there and elsewhere, one hundred up to two hundred miles an hour, the cars will have to be made of special forms to resist the enormous pressure of the air at these high velocities, and specially ventilated; whilst the effective horse-power required to be supplied by the motor will greatly increase the weight of the car.

E. F. Bamber.

EDUCATIONAL AGRICULTURAL EXPERIMENTS.

THE Agricultural Research Association of Scotland was founded for the purpose of obtaining trustworthy and useful information on agricultural subjects, by means of scientific investigation and practical experiments. The report of the committee for 1893 shows that the work of the association continues to proceed satisfactorily. Research work is always difficult to maintain, and a committee fostering it must regard it as an unavoidable, though unpleasant, duty to press its claims. "It is a matter of much regret to the committee," we read, "that we should have so constantly to press for adequate means to carry out the work, and that progress should so constantly be checked for want of means. But the reason is obvious, for an association confining itself to investigation holds a peculiar position. It is different, on the one hand, from organisations that are enabled to return interest for the money spent; and, on

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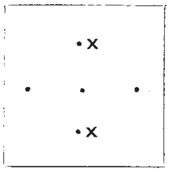
the other hand, from those benevolent institutions from which no interest is expected. An experiment can never be in itself a source of money profit. Benefit may be regarded as certain; but while at times it may be immediate, it is often remote, and not unfrequently the benefit is derived in practice without crediting, or even tracing, the source from which the benefit has sprung."

Among other matters in the report from which this extract has been taken, is a description of educational agricultural experiments intended to be performed by schoolmasters in country districts. The suggestion that a scheme of simple experiments should be framed, such as teachers might suitably carry out for illustration, was made at a meeting of the Institute of Agricultural Education for the North-Eastern Counties of Scotland, consisting exclusively of certificated teachers of agriculture. Mr. T. Jamieson, Mr. W. A. Simpson, and Mr. Gavin Grieg, have now drawn up a scheme on the lines proposed. To show the effects of partial manuring, they suggest a series of tests, such as those shown from A to F, inclusive, in Fig 1. A will thus exhibit the effect of nitrogen alone; B, of potassium alone; C, of phosphorus; D, of nitrogen and phosphorus; E, of phosphorus and potassium; and F, of potassium and nitrogen. The series of experiments indicated by 1 to 6 in the figure have been designed to show the effect of complete manuring. No. 5, having no manure, will afford a comparison with the others. No. 6 will show the effect of complete manuring, as given in the usual manure mixtures. No. 1 to 4, inclusive, will show the effect of new forms of phosphate proposed for manure. For the steeping of the seeds in No. 2, a solution containing about one or two per cent. of potassium carbonate should be made, and the seeds allowed to lie in it for about twelve hours. The committee have prepared full directions as to the manner in which the experiments should be carried out. Twelve flower-pots are required, or wooden boxes, 9 × 9 × 12 inches deep. The soil with which these are to be filled should be dug out from a cavity 6 × 3 × 1 foot deep, and intimately mixed. It is suggested that five seeds be inserted in each pot or box, thus :—



Fifty days after sowing, the two plants marked × have to be taken up and sent to Mr. Jamieson, at the Research Station, Peterculter, Aberdeen, together with a 1 lb. sample of the soil employed. The experiments from Nos. 1 to 6, inclusive, will thus afford comparison with the farm trials to be performed by farmers in different parts of Scotland. The scheme will therefore not only prove of great educational advantage, but will lead to results of scientific value.

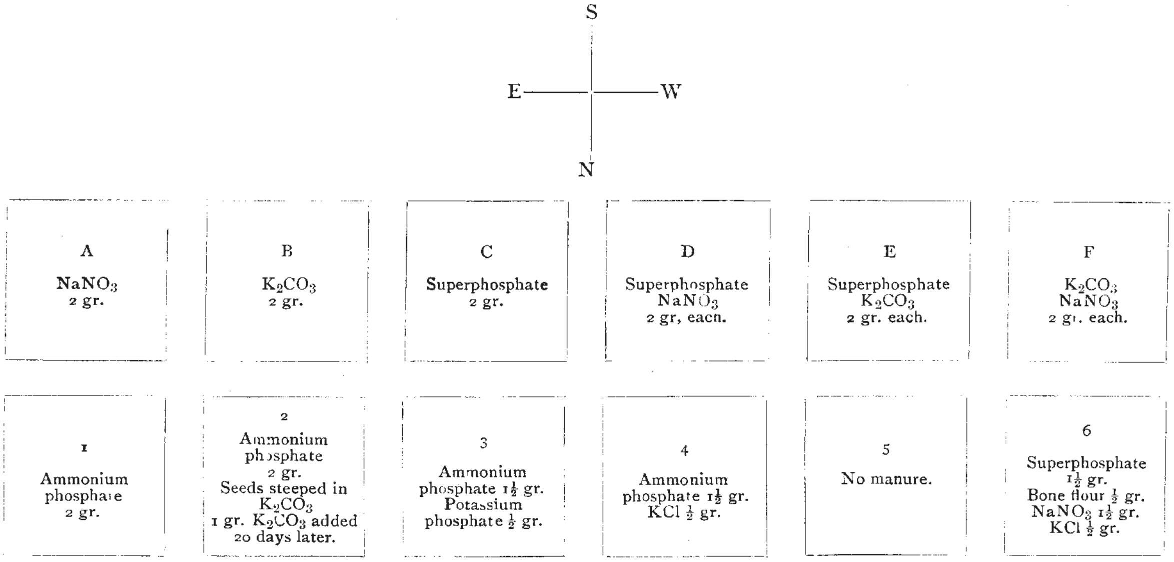

S
E
W
N
A
$NaNO_3$
2 gr.
B
K_2CO_3
2 gr.
C
Superphosphate
2 gr.
D
Superphosphate
$NaNO_3$
2 gr, each.
E
Superphosphate
K_2CO_3
2 gr. each.
F
K_2CO_3
$NaNO_3$
2 gr. each.
1
Ammonium phosphate
2 gr.
2
Ammonium phosphate
2 gr.
Seeds steeped in K_2CO_3
1 gr. K_2CO_3 added 20 days later.
3
Ammonium phosphate $1\frac{1}{2}$ gr.
Potassium phosphate $\frac{1}{2}$ gr.
4
Ammonium phosphate $1\frac{1}{2}$ gr.
KCl $\frac{1}{2}$ gr.
5
No manure.
6
Superphosphate $1\frac{1}{2}$ gr.
Bone flour $\frac{1}{2}$ gr.
$NaNO_3$ $1\frac{1}{2}$ gr.
KCl $\frac{1}{2}$ gr.

FIG. 1.

THE INFLUENZA EPIDEMIC IN GERMANY IN 1889–90.

THE patient compilation of countless facts, and their elaborate arrangement, is a task in the performance of which the Germans are *facile princeps*. If any fresh instance were required, we need only refer the reader to the official report, which has just been issued, of the history of the influenza epidemic which spread through Germany in the years 1889–90. This document covers upwards of two hundred pages of the large quarto volume containing the "Arbeiten aus dem Kaiserlichen Gesundheitsamte," and has been drawn up by Dr. Paul L. Friedrich, Königlicher Sächsische Assistenzarzt I. Klasse, Kommandirt zum Kaiserlichen Gesundheitsamte.

No pains have been spared to secure, as far as possible, trustworthy official data from all parts of the country concerning the various factors intimately connected with the epidemic. The first forty pages of the report contain elaborate details and statistics as to the dates when influenza first made its appearance, and the period during which it remained, in the various provinces and cities of the empire. From the information collected it appears that Berlin and Charlottenburg were the first districts in which it declared itself. Statistics have also been gathered together of the varying intensity of the scourge in different parts of the country, and an endeavour has been made to ascertain the influence, if any, of different occupations on the path pursued by the epidemic. So many conflicting reports were received as to the effect exercised by the kind of employment on the susceptibility of the individual to influenza, that it was impossible to arrive at any definite conclusion. In some districts the evidence went to show that a remarkable immunity to the disease was exhibited by people engaged in *out-door* occupations, whilst from other parts the statistics collected pointed equally strongly to the freedom from attacks exhibited by workpeople employed *within doors*. In some glass works, however, careful observations showed that the employés who succumbed first to influenza were those who were farthest removed from the furnaces, and that those whose work was to remove the glass from the latter, and who were therefore working in a very heated atmosphere, enjoyed a remarkable immunity. Dr. Heiszler, who is responsible for these observations, ascribes the undoubted freedom from influenza experienced by these workpeople, to the air in the immediate

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